West Africa Rice Development Association

Manual of Operations and Procedures of INGER-Africa

CGIAR

WARDA Training Series

WARDA ADRAO

About the West Africa Rice Development Association (WARDA)

The West Africa Rice Development Association (WARDA) is an autonomous intergovernmental research association with a mission to contribute to food security and poverty eradication in poor rural and urban populations, particularly in West and Central Africa, through research, partnerships, capacity strengthening and policy support on rice-based systems, and in ways that promote sustainable agricultural development based on environmentally sound management of natural resources.

In collaboration with the national agricultural research systems (NARS) of member states, academic institutions, international donors and other organizations, the work of WARDA ultimately benefits West African farmers—mostly small-scale producers—who cultivate rice, as well as the millions of African families who eat rice as a staple food.

WARDA was formed in 1971 by 11 West African countries with the assistance of the United Nations Development Programme (UNDP), the Food and Agriculture Organization of the United Nations (FAO), and the Economic Commission for Africa (ECA). It now comprises 17 member states: Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, The Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo.

WARDA is a member of the Consultative Group on International Agricultural Research (CGIAR), a network of 16 international research centers supported by more than 50 public- and private-sector donors.

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INGER-Africa

Background

The goal of the International Network for Genetic Evaluation of Rice for Africa (INGER-Africa), created in 1985 and located at the International Institute of Tropical Agriculture (IITA), Ibadan, was to provide scientists with wide range of genetic materials and access to a network in which their breeding lines could be tested across different conditions. Since 1991, the West Africa Rice Development Association (WARDA) and its national agricultural research systems (NARS) partners have established varietal improvement Task Forces (TFs) for Upland, Lowland, Irrigated and Mangrove Swamp rice breeding activities.

The Consultative Group on International Agricultural Research (CGIAR) Technical Advisory Committee (TAC) review of IITA in 1990 recommended that INGER-Africa be relocated to WARDA. This was reaffirmed by the TAC review of WARDA in 1993. This would bring together the more effective NARS linkages and targeting established by the WARDA TFs with the broader coverage of the INGER network. Between 1994 and 1996, the UK Overseas Development Administration (ODA) funded a project with the main purposes of transferring INGER activities to WARDA, establishing of rice nurseries and seed-handling facilities, improving INGER–NARS linkages, and developing a long-term operational and financing plan.

The transfer of INGER operations to WARDA was effective in April 1997.

INGER Nurseries

New approaches have been developed to adapt INGER nurseries to the Task Force mechanism. Nurseries are now composed according to the following principles.

Access to germplasm: To provide NARS with improved germplasm from a wide range of sources in order to broaden the genetic base of their breeding materials and to identify materials for direct introduction. In this category we have Observational Nurseries (ON), Observational Yield Trials (OYT), and Replicated Trials for grain yield (RYT). These nurseries are composed for each NARS taking into account the specific combinations of traits they request.

Stress-related nurseries (screening at hot-spot locations): To provide NARS scientists with a mechanism to screen their genetic materials for resistance/tolerance to specific stresses at reliable hot-spot locations in the region. Each nursery consists of nominations from NARS and WARDA.

Regional yield stability and adaptability testing: To provide NARS scientists with the means to test the agronomic stability and adaptability of their elite lines in multilocational regional trials. Promising lines nominated by NARS are used to compose these trials. The same number of common entries is evaluated in regional replicated trials for grain yield and plant type, or for resistance to stresses, or both. Such trials provide information on the genotype × environment interactions and the wide adaptability of the promising lines.

Handling segregating populations: Upon request, segregating populations from F_3 to advanced generation can be received from

breeders, grown and harvested in bulk for distribution to NARS for *in situ* selection and advancement nationally.

The type of nursery distributed each year to Task Force members varies. The following are the most common nurseries for Upland, Rainfed Lowland, Irrigated Lowland, and Mangrove Swamp ecosystems distributed to NARS.

Upland Rice Nurseries

I. High Yield

1. Observational Nursery—short & medium duration
2. Observational Yield Trial—short & medium duration
3. Replicated Yield Trial—short & medium duration

II. Stress Screening Nurseries

1. Screening for Acidity Tolerance
2. Screening for Blast Resistance
3. Screening for Drought Tolerance

III. Regional Stability & Adaptability Yield Trial

IV. Segregating Populations

1. Segregating Populations for Acidity Tolerance
2. Segregating Populations for Drought Tolerance
3. Segregating Populations for Weed Competitiveness
4. Segregating Populations for Blast Resistance

Rainfed Lowland Rice

I. High Yield

1. Observational Nursery—short & medium duration
2. Observational Yield Trial—short & medium duration
3. Replicated Yield Trial—short & medium duration

II. Stress Screening Nurseries

1. Screening for Blast Resistance
2. Screening for Drought Tolerance
3. Screening for Iron Toxicity Tolerance
4. Screening for African Rice Gall Midge Resistance
5. Screening for Rice Yellow Mottle Virus Resistance
6. Screening for Low-Input conditions

III. Regional Stability & Adaptability Yield Trial

IV. Segregating Populations

1. Segregating Populations for Blast Resistance
2. Segregating Populations for Drought Tolerance
3. Segregating Populations for Rice Yellow Mottle Virus Resistance
4. Segregating Populations for African Rice Gall Midge Resistance
5. Segregating Populations for Iron Toxicity Tolerance

Irrigated Rice

I. Yield and Grain Quality

1. Observational Nursery—short & medium duration
2. Observational Yield Trials—short & medium duration
3. Replicated Yield Trials—short & medium duration

II. Stress Screening Nurseries

1. Screening for African Rice Gall Midge Resistance
2. Screening for Rice Yellow Mottle Virus Resistance
3. Screening for Cold Tolerance

III. Regional Stability & Adaptability Yield Trial

IV. Segregating Populations

Segregating Populations for Rice Yellow Mottle Virus Resistance

Mangrove Swamp Rice

I. High Yield

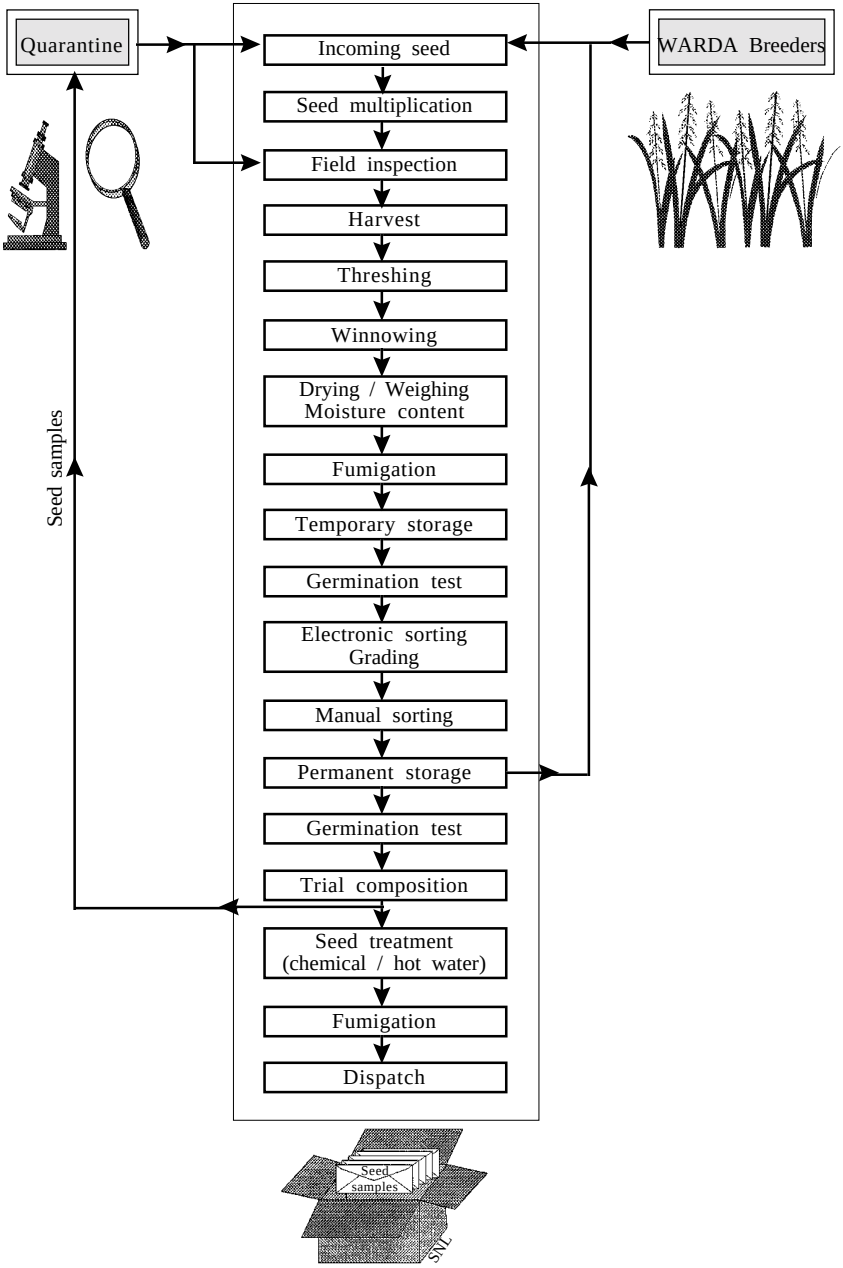
1. Observational Nursery—short, medium & long duration
2. Observational Yield Trial—short, medium & long duration
3. Replicated Yield Trial—short, medium & long duration

II. Stress Screening Nurseries

1. Screening for Salinity Tolerance
2. Screening for Acidity Tolerance

III. Regional Stability & Adaptability Yield Trial

IV. Segregating Populations



INGER-Africa Operations

Seed Receipt and Seed Preparation

Seeds to be included in INGER nurseries are nominated by either WARDA or NARS breeders. Lines nominated are sent to INGER by mail or hand-carried by scientists visiting WARDA. A database is developed for any line newly received, which documents the following descriptors:

- plant introduction (PI) code
- year of receipt
- (variety) name
- origin
- ecology
- genetic type
- parentage
- donor information.

Field Operations

Seed Production of Lowland Rice

Seed Bed Preparation

The type of seed bed used is a wet bed. The seed bed area is plowed and cultivated by several passings of a machine-drawn rotovator. Beds are raised approximately 15 cm above the ground and furrows are made on the bed using a furrower, with 10 cm between rows. Sometimes furrows are made using rulers and seeding rows.

The number of rows and their length is determined by the size of the field. For example, for a 40 m^2 plot with a seed rate of 100–120 g, 10–13 rows of 1.5 m length should be used, i.e approximately 10 g per row.

Labeling

Labels are placed at the start of each entry. The name of the entry, the name of the trial and the serial number of the entry are written on the label. A small amount of fertilizer is applied: about 5 g/m^2 of ammonium sulfate (21-0-0) or approximately 10 kg N per hectare. Seeds are sown evenly on the assigned rows for each accession. The seed bed is covered with top-soil ('black soil'). Granular insecticide, e.g. carbofuran, is applied to control ants and crickets; this can also control nematodes. The seedlings will remain in these plots for approximately three weeks.

Water management

The seed bed is flooded. To avoid mixing-up of seed samples, do not submerge the beds. Irrigation is done intermittently. The soil is maintained moist for 0 to 3 days after planting. Thereafter, irrigation is done in the morning and water is drained in the evening. This is more important during the cold period to avoid the seedlings suffering at night. At 8 to 15 days after planting, water level is maintained at 3–4 cm depth in the furrow; 15 to 18 days after planting, water is drained to allow seedlings to establish their root systems.

Pulling and pre-pulling preparation

The seed beds are flooded, ideally to 3–5 cm above the bed. This will facilitate pulling and washing of soil from the roots. Pull the seedlings carefully and put them in a tray. Each entry is put together with its tag in a tray. Note plant stand to decide what further action is needed on a particular accession, e.g. modifying plot size. After pulling, arrange the seedlings by ascending plot numbers in seedling trays.

Land preparation

Land preparation consists of one plowing and 2–3 passings of harrow or rotovator. The final stage of land preparation is leveling.

Treatment

To control weeds, herbicides are applied. Two products are mainly used:

- Gramoxone at a rate of 2 or 3 L/ha, at least 3 days before transplanting; plus,
- Ronstar at a rate of 5 L/ha after transplanting.

To control insects and nematodes, apply:

- Decis at a rate of 2.5 L/ha; for flying insects and,
- Granular insecticide, e.g. carbofuran at a rate of 50–60 kg/ha for nematodes.

Transplanting/replanting

Transplant three-week old seedlings using rulers and ropes as planting guides, with 1–2 seedlings per hill.

Collect excess seedlings of each entry and place them near the labels. More healthy replanting materials can be obtained if they are divided in smaller bundles and properly placed in the paddy.

Fertilizer application

As basal: 10-18-18 NPK at 150 kg/ha
or 75 kg TSP/ha + 75 kg urea/ha
First top-dressing: 50 kg/ha 30 DAS

Second top-dressing: 50 kg urea/ha 45 DAS
Third top-dressing: 50 kg urea/ha 60–70 DAS

N.B.: For mangrove swamp rice, the dose of fertilizer should be reduced in order to avoid lodging:

As basal: 10-18-18 NPK at 75 kg/ha
or 37.5 kg TSP/ha + 37.5 kg urea/ha
First top-dressing: 25 kg urea/ha 30 DAS
Second top-dressing: 25 kg urea/ha 45 DAS
Third top-dressing: 25 kg urea/ha 60–70 DAS

Irrigation and water management

In seed multiplication plots, furrow irrigation is done and the field should have a good irrigation system and excellent drainage to allow good water control. During land preparation, the water level should be maintained to keep the soil soft prior to transplanting. Irrigation is done intermittently throughout the cropping season so as not to submerge all the materials. Maintain 3–5 cm level of water during the early stage of crop to control early growth of weeds.

Purification

Roguing is one of the most important activities during seed multiplication. Before pulling and after replanting in the field, rogue-out rice plants growing off the row. These are assumed to be dropseeds or volunteer seeds. At the late vegetative stage, obvious off-types should be removed. Re-identify the plants by comparing the seeds with the seed file. This is to ensure genetic identity and uniformity of the seed. Note that this should be done several times as the flowering period varies among lines.

In addition, final purification should be done during seed processing. During vegetative and reproductive stage, roguing should be done based on agronomic traits and morphological characteristics:

- plant color
- plant height
- leaf shape
- tillering ability
- cycle
- panicle type
- awn
- grain color
- grain shape
- apex color
- plant architecture.

Field inspection

At maturity, a team of national plant protection officers undertake a thorough inspection of individual plots in order to issue the phytosanitary certificate.

Data collection

A minimum data set is collected during seed production: plant height, duration, panicles/m^2, and reaction to diseases and soil problems.

Harvesting

This is a critical phase of seed production, which if inadequately carried out can result in deterioration of quality or total loss of seeds.

After removing all the off-types, harvest should start from the entry which flowers first.

As harvesting approaches, the plants must be observed daily, and the panicles on the most mature tillers inspected. Water is drained from the paddy rice field 1 to 1½ weeks before harvesting in irrigated conditions. Harvesting should be carried out when the hulled grains on the upper portion of the panicle are clear and firm and most of the grain at the base of the panicle is in the hard dough stage. At this time at least 80% of the grains are straw-colored. The moisture content should be 20–25%. The harvest is done manually and each panicle is harvested separately and then put together in a bag with corresponding labels and then sun-dried.

Seed Production of Upland Rice

1. Under lowland conditions

The different operations are similar to seed production of lowland rice except for irrigation and water management.

Irrigation and water management

If upland material is grown in irrigated lowland conditions, water should not be maintained after transplanting. At early stage most of the plants will die if water is maintained in the plots. The soil is kept moist at the vegetative stage, and 2–3 cm level of water is maintained at the reproductive phase. The field should have a good irrigation system and excellent drainage to allow good water control.

2. Under upland conditions

Land preparation

Land preparation consists of two main tillage operations:

- Plowing: a deep primary tillage, which is the initial breaking and turning over of the soil between the harvest of one crop and the planting of the next. Plowing incorporates weed seeds and crop stubble into the soil.
- Harrowing/puddling: a shallow secondary tillage which breaks up big soil clods and further incorporates weed seeds and stubble into the reduced soil layer, where lack of oxygen inhibits weed seed germination.

Planting

Seeds are directly planted in lines or in hills. During the rainy season, planting is generally done after a favorable rain. During the dry season, irrigation is done immediately after planting to facilitate good germination.

Irrigation

Sprinkler irrigation is practised in upland conditions. During the rainy season, irrigation is done whenever the rain stops for a while. During the off-season irrigation is done as needed.

Fertilizer application

NPK (10-18-18) is applied as basal at a rate of 200 kg/ha during land preparation.

Urea: 65 kg/ha as first top-dressing at tillering and 65 kg/ha as second top-dressing at booting stage.

Purification, field inspection, data collection and harvesting operations are similar to lowland conditions.

Postharvest operations

The postharvest operations are applied to both lowland rice and upland rice produced in lowland and upland conditions.

Threshing

Threshing involves the detachment of paddy kernels from the panicle; it is done manually.

Treading by feet, flail-threshing, and beating on tubs, threshing boards, mats or racks are the most common methods of manual threshing. It should be done smoothly in order to avoid breakage.

Drying

After threshing, the seeds are sun-dried or a batch dryer is used. In the batch dryer, heated air passes through the grain and absorbs evaporating moisture.

For short-term storage (i.e. less than one year), the seed is dried to 9–12% moisture content. If storage might be extended for a considerably longer period, seed is dried to below 10% moisture content. Aeration with dry, cool air generally improves environmental conditions for seed rice in bulk storage.

Winnowing

Winnowing is generally done by women, who use round, flat trays or baskets to toss the grains into the air, allowing the breeze to separate the chaff.

Cleaning of grain involves the separation of bulk straw, chaff, empty kernels, and very light and fine impurities from the grain.

Straw and chaff are manually separated and the grain is dropped through a cross-wind to remove the lighter impurities. Air can only remove impurities that have different aerodynamic properties from the grain.

Moisture content reading

After blowing and threshing, moisture content should be determined by a moisture tester. Seed should be stored when the moisture content is below 10%. If the moisture content is higher than normal, the seed should be sun-dried.

Viability test

Germination tests are performed regularly to monitor seed viability. Seeds stored in a cold room are tested at regular intervals during storage. Any varieties that had a rate of germination below 80% are multiplied to regenerate the seed.

Seed sorting

Seed sorting is done manually by a well-trained technician. This is done to improve the quality of the seed lot by separating weed seeds and inert matter, and eliminating poor-quality seeds and off-types. In addition, discolored, deformed, infected, soiled, immature and damaged seeds should be removed.

Seed storage

Seeds are stored in two different conditions:

1. Storage at 20°C

For short-term storage, the seed is kept in a store at a temperature of 20°C. The seed stored in such conditions is not usually sorted. The total amount of seed harvested is kept in the room for early distribution.

2. Storage at 10°C

Some 5 kg of clean seed per variety is kept in the cold room for medium-term storage at a constant temperature of 10°C and 40% humidity.

Data Management

Data management involves many commercial and written programs, which are being created or modified as need arises. Every variety is given an accession code on receipt. Information of the origin, source, ecology, duration, seed quantity and date of receipt are entered in the computer. After harvest, field data, seed quantity, location on the shelves and germination rate are also recorded in the computer. Several computer programs have been written for easy varietal and information retrieval for trial composition and varietal supply. Data sets basically comprise passport data, characterization and evaluation data.

Management of the store and cold store: Seed inventory and distribution data

In addition to location of the varieties in the store and the cold store, it is important to know the effective quantity of seed available at any time. To have this information, all the in- and out-goings must be managed effectively when they occur. There are set of programs with a menu, which control these movements and also make requests about a given period, variety or destination.

Input/output files

The seed movements are very important because they must be followed in order to know the actual quantities of seed remaining in the store and the cold store. These movements are retrieved in different input or output files.

Database updating

The database is the basic information system of the varieties. Continuous updating is necessary to give credibility and safety to the data supplied. New varieties must be entered into the database on receipt. Modifications concerning characteristics must also be entered when known.

Varietal request in the database

This program tells the user whether the variety he/she is looking for is available in the database. After the entry of the whole name or part of the name, the computer will display the list of the varieties which match the query. Once the required variety is located, press the <Enter> key to display the characteristics of the given variety. Additionally, the list could be printed to produce a catalog of the quantities and the locations of the varieties in the stores.

Printing tags

With the variety codes retrieved in a file, we can print tags (labels). The program prints the tags automatically without asking for the names of varieties and the other information it needs.

Printing list of varieties or field book

When dispatching varieties in trials, field books must be included with the necessary information like designation or variety name, the cross, the origin of the varieties and germination rate.

To make data collection easy, the field books must be printed with all the replications and the different kinds of notes to be taken. These printing are either in English or French depending on the official language spoken in the country of seed receipt.

Trial Composition

The principles of trial composition are:

- Provide genetic diversity and variability.
- Targeted supply of valuable germplasm to increase the share of useful materials to a particular NARS.
- Avoid overloading the NARS.

Nursery Dispatch

Seeds to be sent are packed in polyethylene sheets properly sealed with a heat-sealing machine after being treated with fungicide and insecticide.

Additional documents are put together in the seed boxes:

- protocols
- varietal list
- phytosanitary certificate.

Phytosanitary Certificate

A phytosanitary certificate is delivered by the Department of Agriculture in Bouaké after field inspection. Some countries require an Import Permit to be attached to the package.

Conclusion

A number of varieties received from WARDA breeders and NARS are multiplied under upland and lowland conditions.

Seeds are sent to different countries based on individual requests for trials. From 1994 to 1997, a total of 5265 rice varieties (1491 upland, 549 irrigated, 1615 rainfed and 1610 mangrove) were multiplied.

During Task Force meetings, national program scientists make their nursery requests. They specify the types of nursery they need, the number of varieties per nursery, the varietal characteristics and the deadline for the seeds to be sent to them.

This mechanism presents several advantages: (1) nurseries are tailored to the individual country needs; (2) each country is only given useful genetic materials adapted to its environments and farmers' preferences; (3) fast genetic gain is achieved and good varieties can reach farmers' fields in a short period of time.

Thus, a number of varieties have been released or are in the pipeline for release in several countries. Other outstanding varieties are at advanced stages of selection. Below is the list of varieties released or in the pipeline for release throughout West Africa as reported by NARS scientists during Task Force meetings in April 1997. These materials were introduced by the national program breeders through the Task Force germplasm exchange mechanism in 1992 or later.

Achievements

Upland Rice

Country	Varieties released or proposed for release
Côte d'Ivoire	WAB 56-50 (resistant to blast and drought) WAB 56-104 WAB 96-1-1 (weed competitive) WAB 56-125
Burkina Faso	WAB 56-50 WAB 56-39 WAB 56-125
Cameroon	WAB 384-B-B-3-1-2 WAB 96-1-1
The Gambia	WAB 56-50
Guinea Bissau	WAB 56-50 WAB 96-1-1
Liberia	WAB 56-50 WAB 56-104 WAB 96-1-1
Nigeria	WAB 36-2LFX WAB 36-34-FX WAB 56-125
Sierra Leone	WAB 96-1-1 LAC 23

Irrigated Lowland Rice

Country	Varieties released or proposed for release
Côte d'Ivoire	WITA 1 (tolerant to iron toxicity and blast) WITA 3 (tolerant to iron toxicity and blast) WITA 7 (resistant to RYMV) WITA 8 (tolerant to RYMV) WITA 9 (resistant to RYMV)
Mali	IR 1561-228-3-3 IR 32307-107 KOGONI 91-1 RPK N2
Mauritania	Sahel 108 (IR 13240-108-2-2-3) Sahel 201 (BW 292-3) Sahel 202 (ITA 306)
Niger	WITA 8 WITA 9
Senegal	Sahel 108 (IR 13240-108-2-2-3) Sahel 201 (BW 292-3) Sahel 202 (ITA 306)
Sierra Leone	Mashuri (ROK 25)

Rainfed Lowland Rice

Country	Varieties released or proposed for release
Chad	Tox 728-1
Côte d'Ivoire	WAB 638-1 (aromatic)
Guinea	Suakoko 8 CK 211 CK 4 CK 73
Senegal	BW 248-1
Sierra Leone	Suakoko 8

Mangrove Swamp Rice

Country	Varieties released or proposed for release
The Gambia	WAR 1 WAR 77-3-2-2 ROHYB4 ROHYB6 ROK 5 WAR 100-2-11-1 WAR 115-108-1-8 WAR 81-2-1-2
Guinea	WAR 1 B 38D2 ROK5 WAR 77-3-2-2 BW 295-5 WAR 73-1-M-1 ROHYB6

Guinea Bissau	WAR 115-111-2-3
	WAR 81-2-1-2
	WAR 77-3-2-2
	RD 15
	ROHYB4
	ROHYB6
Nigeria	BG 380-2
	WAR 77-3-2-2
	ROHYB6
	ROHYB4
	WAR 81-2-3-3-3-1
Senegal	WAR 77-3-2-2
	WAR 1
	ROK 5
	WAR 81-2-1-3-2
Sierra Leone	WAR 1
	WAR 77-3-2-2
	WAR 81-2-1-2
	ROHYB4
	ROK5
	ROK 10
	CP4

Most of these varieties have shown stable yield and stress tolerance across countries and are already in farmers' fields.

About the Consultative Group on International Agricultural Research (CGIAR)

The Consultative Group on International Agricultural Research (CGIAR) was founded in 1971 as a global endeavor of cooperation and goodwill. The CGlAR's mission is to contribute, through its research, to promoting sustainable agriculture for food security in developing countries. The CGIAR works to help ensure food security for the twenty-first century through its network of 16 international and autonomous research centers, including WARDA. Together, the centers conduct research on crops, livestock, fisheries, and forests, develop policy initiatives, strengthen national agricultural organizations, and promote sustainable resource management practices that help provide people worldwide with better livelihoods.

The CGIAR works in partnership with national governmental and non-governmental organizations, universities, and private industry. The United Nations Development Programme, the United Nations Environment Programme, the World Bank, and the Food and Agriculture Organization of the United Nations sponsor the CGIAR. The CGlAR's 57 members include developing and developed countries, private foundations, and international and regional organizations. Developing world participation has doubled in recent years. All members of the OECD (Organisation for Economic Co-operation and Development) Development Assistance Committee belong to the CGIAR.

The CGIAR is actively planning for the world's food needs well into the next century. It will continue to do so with its mission always in mind and with its constant allegiance to scientific excellence.

CGIAR Centers

CIAT	Centro Internacional de Agricultura Tropical (Cali, Colombia)
CIFOR	Center for International Forestry Research (Bogor, Indonesia)
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo (Mexico, DF, Mexico)
CIP	Centro Internacional de la Papa (Lima, Peru)
ICARDA	International Center for Agricultural Research in the Dry Areas (Aleppo, Syria)
ICLARM	International Center for Living Aquatic Resources Management (Manila, Philippines)
ICRAF	International Centre for Research in Agroforestry (Nairobi, Kenya)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics (Hyderabad, India)
IFPRI	International Food Policy Research Institute (Washington, DC, USA)
IITA	International Institute of Tropical Agriculture (Ibadan, Nigeria)
ILRI	International Livestock Research Institute (Nairobi, Kenya and Addis-Ababa, Ethiopia)
IPGRI	International Plant Genetic Resources Institute (Rome, Italy)
IRRI	International Rice Research Institute (Los Baños, Philippines)
ISNAR	International Service for National Agricultural Research (The Hague, Netherlands)
IWMI	International Water Management Institute (Colombo, Sri Lanka)
WARDA	West Africa Rice Development Association (Bouaké, Côte d'Ivoire)

West Africa Rice Development Association

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